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Final Technical Report: History of the Combat Training Center Archive

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The purpose of this document is to report developments towards meeting the mission to provide vital and responsive information to the Army. The following is a documentation of the database development and what eventually became known as the CTC Archive which played a critical role in achieving the Army wide lessons learned mission.

The information here serves several purposes:

a) To share what has been learned through the processes of creating a useable database.
b) To outline what information was available through the CTC Archive.
c) To document how military analysts and researchers have used the CTC Archive to develop lessons learned for the Army.

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HISTORY OF THE COMBAT TRAINING CENTER ARCHIVE

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HISTORY OF THE COMBAT TRAINING CENTER ARCHIVE

Contents

EXECUTIVE SUMMARY

The National Training Center (NTC) was instituted in 1979 at Ft. Irwin, California to provide a central, realistic training facility for combined arms combat training. The NTC was given two missions: a) to provide realistic, essential combined arms training; and, b) to gather data on the effectiveness of current and emerging doctrine, force structure, organization, materiel systems and training management approaches (Edwards, 1979). Units began arriving at the NTC for training in late 1981. Two additional Combat Training Centers (CTC) were added during years 1987 to 1988; Joint Readiness Training Center (JRTC) and the Combat Maneuver Training Center (CMTC). At the inception of NTC, deriving information and data was integral to obtaining the full value for the Army. However, due to start-up difficulties and organizational changes, the second mission was not addressed until 1985.

In 1985, Combined Arms Training Activity (CATA) contracted with the U.S. Army Research Institute for the Behavioral and Social Sciences at the Presidio of Monterey, California (ARI-POM) to begin the process of extracting information from the data generated at the NTC (LOA, 1985). The CTCs generated data through their instrumentation systems, observations provided during training, and feedback provided for home-station training. The data were not generated from an analytical perspective, but solely from a feedback and training perspective. While these data sources were merely by-products of the training effort, they provided the Army with an opportunity to extract information to assess combat readiness, needed training improvements, and effectiveness of new equipment and organizations. ARI-POM, in conjunction with the BDM Corporation, developed and brought to an operational status a CTC research database, named the CTC Archive. As technology advanced, the database likewise evolved. Data sources were reviewed, improved, and integrated. Prototype reports and responsive research issues were produced. Data collection and measurement approaches were developed, proposed and tested to facilitate both feedback to the units and assessment of unit combat readiness. Instruction, tools, and interactive computer programs were developed to enable military analysts the capability to use the CTC Archive.

Over the period of ten years, ARI documented and developed systematic data collection and analyses which provided the Army with lessons learned, trend analyses, and the tools for students and trainers to extract data from the NTC database. The result of CATA's relationship with ARI-POM is a fully operational data collection and analytical system, complete with state of the art databases, training workshops, and workstation instructional documentation. The NTC's, now CTCs', second mission to provide vital and responsive information to the Army was realized. In 1995, ARI-POM turned over to TRADOC a fully operational, user friendly research database which satisfied both the military and research community research requirements.

The purpose of this document is to report developments towards meeting the second mission. The following is a documentation of the database development and what eventually became known as the CTC Archive which played a critical role in achieving the Army wide lessons learned mission. The information here serves several purposes: a) to share what has been learned

through the process of creating a useable database; b) to outline what information was available through the CTC Archive; and c) to document how military analysts and researchers have used the CTC Archive to develop lessons learned for the Army.

CHAPTER I
TRADOC EFFORTS TO DERIVE ARMY-WIDE LESSONS LEARNED 1979-1985

The Combat Training Centers (CTCs) provide realistic combat environments by employing simulated weaponry and simulated battlefield effects. These battlefields are as realistic as they possibly can be without the loss of life. CTCs are learning environments which provide units a test of their combat readiness and feedback to guide unit training. Early on, the Army recognized the need to objectively measure the effectiveness and efficiency of organizations and weapon systems. The CTC developers realized the unique opportunity to provide not only units combat experience, but also institutional feedback to the Army (Chapman, 1992; Edwards, 1979; GAO Report 1986).

The Development Plan clearly outlined a procedure and requirement to develop a standardized evaluation of performance and effectiveness, thereby providing a resource for both analysis and feedback (Edwards, 1979). However, this requirement was not met. Institutional feedback for the Army was superseded by the need to provide unit feedback. Hence, institutional feedback had to be derived from data generated for units.

The Combined Arms Center (CAC) and the combined arms schools were given the responsibility to develop analytical measures in coordination with the instrumentation development conducted by HQ TRADOC (Edwards, 1979). The NTC Database was to be maintained to provide FORSCOM and TRADOC information required to assess combat readiness, develop and assess training programs and doctrine, assess force development and weapon requirements, and to improve combat simulations (Edwards, 1979). While the core instrumentation system (CIS) was designed with the ability to electronically track players, weapons, and vehicles, data collection provisions for analysts were not included (Chapman, 1992; GAO Letter, 1986).

The National Training Center (NTC) at Ft. Irwin, California, the first combat training center, was instituted in 1979. It was designed with a laser based instrumentation system which simulated casualties and firings to create a realistic battlefield environment. The instrumentation system was also designed to track soldiers and vehicles as the battle occurred. Part of the training experience was to provide feedback during the training events. Information gathered electronically and from the Observer/Controllers (OCs) was designated by the development plan as the major input into the feedback, termed After Action Reviews (AARs). A portion of the Operations Group, the Training Analysis and Feedback (TAF) division, was to synthesize this information with video and communications information into an AAR package for each mission (Edwards, 1979). Start-up difficulties necessitated a different approach which permanently influenced the production of AARs and impacted the generation of data for analysts.

When the first Army maneuver battalions arrived at NTC for training in 1981, the instrumentation system was still suffering start-up difficulties (Chapman, 1992). The CIS was initially conceived as an integral part of the process of developing AARs for units during training. AARs were part of the "train-evaluate-train" system of the NTC (Edwards, 1979). After missions were conducted, units from the very lowest echelon to the highest echelon were provided information on their performance, both strengths and weaknesses (Chapman, 1992). Many

problems existed with the instrumented data collection system which spanned the continuum from players and vehicles which were uninstrumented and therefore could not be tracked, to the system's inability to track concealed vehicles and personnel, to total breakdown of the CIS (Chapman, 1992; Shackelford, 1985).

Originally, the CIS information was to be processed by the TAF division. The TAF consisted of two training analysis teams: one designated to analyze armor battalion task performance, and the other to analyze the mechanized infantry battalion task force. These training analysts were initially to provide all the training feedback needed for the AARs using the instrumented data (Chapman, 1992; Edwards, 1979). However, the instrumentation system was unable to provide information for AARs during the first year of rotations. Thus, the OCs began conducting the AARs because they were closest to battlefield activities. This was well beyond the original scope of duties, responsibilities and intent for the OCs. The OCs' envisioned role had been limited to battlefield operations, such as providing battlefield effects, assisting in the casualty assessment, and enforcing the engagement rules and Multiple Integrated Laser Engagement System (MILES) procedures. The OCs began conducting the AARs using their observations on the battlefield as well as their knowledge of doctrine (Chapman, 1992).

OCs worked with units at all echelons in the field to provide guidance and remained with the units throughout the rotation. While they followed the battle and advised units on how to improve their battle tactics, they compiled subjective observations. At the end of missions, they constructed and presented AARs with information gathered from the instrumentation (when available), video cameras on the field, and their subjective observations. Significant events which affected the battle outcome were isolated for review. Performance strengths and weaknesses were highlighted and reviewed. At the end of the rotation, Take Home Packages (THPs) were compiled from all the AARs and eventually data gathering instruments during the rotation and sent to home stations. THPs became a primary data source for the CTC Archive.

Colonel Shackelford, chief of operations, designed a system of check lists to facilitate and standardize the feedback of OCs. From these notes and input from the OCs, THPs were generated. The checklists did not standardize the AARs however. Banks and Whitmarsh (1984) reviewed the AARs and Take Home Packages and reported that the OCs varied on types and methods of observation and feedback. This hard copy data was initially the only reliable data source, though not objective. Even after the instrumented (CIS) data became available for training evaluation and AARs, these data alone proved unsatisfactory. OCs were able to 'correct' instrumented data errors and determine causes of mission failures and successes through observation. Therefore, OCs continued to present the AARs complemented by the instrumented data produced by the Training Analysis and Feedback Officer (TAFO) (Chapman, 1992; Shackelford, 1985).

Once the training support components were in place and multi-echelon combined arms training was conducted on a routine basis, emphasis was placed on NTC's potential for addressing questions concerning training techniques, equipment, organizations and doctrine (Fobes,1984). By 1984 the instrumentation system was fairly reliable and the generation of THPs consistent. A requirement to establish an R&D Center which had the capability to use NTC instrumented and non-instrumented data for analysis emerged.

Although from inception the NTC was to provide Army wide lessons learned, the ability and commitment to do so was absent. As noted earlier, the NTC Development Plan included a directive to emplace a lessons learned system at the NTC, however the system did not materialize. Brigadier General Frederic J. Brown, III, while serving as Deputy Chief of Staff for Training at TRADOC headquarters in 1981, directed that a plan be defined and developed for using the data generated at the NTC for Army wide institutional feedback two months prior to the first rotation. Although he recommended the establishment of a group of representatives from TRADOC's major subordinate elements to define and develop a 'Lessons Learned', system, no group or system was established (Chapman, 1992).

Brigadier General Frederick J. Brown, III designated CAC as the lead agency to develop lessons learned for the Army. CAC responded by delegating that responsibility to the NTC Division of the Command and General Staff College's (CGSC) Unit Training Support Directorate. CGSC was responsible for repositing NTC data and observations and analyzing the information for lessons learned until 1984 when the CATA was established (Chapman, 1992).

As late as 1983, the problem of deriving systematic, objective lessons learned continued. The NTC was primarily concerned with training difficulties which resulted from the limited number of trained staff (OPFOR) and instrumentation difficulties. Apparently, the issue of a feedback mechanism to the Army was over-ridden by training concerns. Major General Fredrick J. Brown III was commanding the Armor school at the time and raised the issue of processing data from the NTC at a meeting of branch proponent school representatives. However, no actions were taken, nor any concrete system designed nor implemented to extract information for the Army from the NTC. Throughout the history of the NTC, a persistent concern and resistance regarding evaluation, or "tests", at the NTC has thwarted efforts towards any objective measurement of unit performance. FORSCOM unit commanders worried that their performance at the CTCs would adversely affect their assignments and promotions, and therefore resisted any objective measurement of unit performance (Chapman, 1992).

While the Army and TRADOC proponents continued to be concerned about using the NTC data to the fullest, in 1984 there still existed no method for integrating the data into one database for analysis, or a systematic method of generating lessons learned. CAC published lessons learned for battalion task force commanders and staff under the title of "Combined Arms Training Tips" (Chapman, 1992), but these were largely anecdotal. These lessons learned were based primarily on commander insights and OC observations at the NTC. The data were not objective, nor were the Combined Arms Training Tips systematically derived.

In 1984, Army Research Institute (ARI) was contacted by TRADOC to assist in the development of NTC data utilization. Initial research products generated by ARI at the Presidio of Monterey (ARI-POM) pertained to the contents and tools with which to examine the data (Dunipace, Henderson, & Smart, 1984; Fobes, 1984; McFann & Avant, 1983; Weaver, Griesmer, & Alan, 1984).

ARI's involvement with CAC provided TRADOC the ability to respond to a General Accounting Office (GAO) investigation which questioned the cost-effectiveness of the NTC during

FY 84-85 (GAO report, 1986). The report cited the extensive turbulence within units after NTC rotations as a reason to shift from exclusive emphasis on training feedback and to begin collecting, analyzing, and processing lessons learned into the Army's institutional memory. At that time, except for ARI and CAC plans, no work was being conducted on the NTC's second mission, to provide information from the NTC regarding systemic Army problems (Banks, 1993; Chapman, 1992).

In August of 1985 another effort was made to institutionalize a lessons learned system (Chapman, 1992). A Center for Army Lessons Learned (CALL) was established at CAC as a directorate of the CATA. In an effort to better manage the NTC data collection, the Army also established a Data Analysis Center at ARI-POM and a Combat Analysis Laboratory at the RAND Arroyo Center at Santa Monica, California.

CATA formally contracted with the ARI in 1985 (LOA, 1985) to establish an R&D center to explore the data generated at the NTC. ARI-POM planned and directed a multimillion dollar Unit Training R&D Center to provide the initial research capability and analytic tools to use the massive amounts of data generated during NTC operations. The commitment by the Army to derive as much as possible from the NTC became substantial.

Acting Commander of the CATA, Colonel Jerome L. Haupt signed an agreement with the Commander of the ARI, Colonel W. Darryl Henderson on 16 September 1985. In this LOA, ARI was directed to begin addressing the CTCs' second mission. ARI was to develop and prototype methods and procedures to assess unit training status, develop NTC training and feedback systems, develop standardized procedures for generating NTC THPs, and provide recommendations for the NTC data base design and application (LOA, 1985).

CHAPTER II
INITIAL DERIVATION OF LESSONS LEARNED

In 1985 ARI was awarded $1.5 million dollars for a 3-year effort to develop performance measures, evaluate the usefulness of NTC instrumented data for analyzing exercise results, and assist in developing an analysis methodology. In the first year, 22 research products and reports were produced (Doherty, 1987). These products were developed in support of ARI's effort to investigate new methodologies for measurement of unit performance and the derivation and dissemination of lessons learned. The BDM corporation, a military contractor, was contracted to assist in a three year investigation entitled: "Research Support for a Unit Home Station Training and Feedback System". BDM played a major role throughout the development and operation of the CTC Archive.

McFann and Avant (1983) explored the data generated at the NTC to determine what data sources existed and their availability for potential use by the Army research community. McFann and Avant (1983) concluded that before the NTC digital database could of any use, it needed to be assessed for fidelity of the simulation, the extent and nature of the simulation, the amount of erroneous or lost data, the extent of pre-editing of the data, and the actual battlefield situation. After the signing of the LOA in 1985, the very first steps towards establishing the R&D center were to examine both the types and quality of data available at the NTC. Systematic processing of the data was required before the research community could effectively use the data generated at the NTC.

Whitmarsh (1987) conducted a study examining the types and quality of the NTC data. He examined the types of NTC information available, research problems regarding collection and merging of information, and data quality issues. The data sources he found available were the Operations Plans, Take Home Packages (THPs), the Company/Team THPs, video taped After Action Reviews (VAARs), Unit After Action Reports (UAARs), and the NTC Instrumentation System (NTC-IS) Data Tapes. Later the Communications Tapes which recorded battlefield transmissions were identified and also sent to ARI-POM. The research problems he identified were in the collecting and merging of the data. All the various sorts of data required integration to provide an effective data source for any analytical effort. No one data source alone could be considered reliable, many errors and omissions occurred due to a lack of collection standardization. Overlap and redundancy in the various data sources permitted correction of erroneous data, identification of missing data, and a more realistic and encompassing view of battlefield activities.

At the end of the initial phase of the NTC Archive, data were routinely collected and forwarded to ARI-POM. The archive contained eight years of data from Armor and Mechanized Infantry Task Force rotations beginning with the first NTC rotation (8101). However, the data beginning fiscal 1986 were more reliable than previous years because sufficient standardization of data collection and rules of engagement had been emplaced. In order to facilitate the use of the CTC Archive, workshops were instituted at ARI-POM to provide analysts the tools and knowledge necessary to derive lessons learned. The data sources identified and processed by this time are

listed in Table 1[1] (Zimmerman, 1989).

In an effort to integrate these various data sources and formats, ARI-POM proposed a system which would include all these elements. This research database was largely realized with the exception of integrating the VAAR, UAARs, or communications tapes into the digital database. In the initial stages of beginning to process NTC generated data, only the THPs and the digitized CIS tapes could be processed into an electronic database. The NTC-IS Data Tapes were entered by tape drive through a NTC Translator/Loader software by a computer system operator. THPs were added through the word processing system. Retrieval of the information was complex and difficult because the instrumentation system was not designed with an analytical perspective (Whitmarsh, 1987).

As early as the first year of taking on responsibility for developing an archive, ARI-POM was deriving lessons learned from the available NTC generated data (Shackelford, 1985). The data sources used for this study were the THPs, the UAARs and the CIS data tapes. The data were derived from 14 battalions which rotated through the NTC from 1982 to 1984. Areas examined were task force performance, main battle tank loss rates, tank and TOW ammunition expenditures compared to historical expenditures, effectiveness of direct fire during defensive missions, NTC combat vehicle loss ratios, live-fire tank gunnery performance, and task force communications security performance. Although the data sources were stable during the time period under study, the reliability of the data had to be considered. Nonetheless, with good military judgement and reasonable data sources, unprecedented studies emerged (Shackelford, 1985). The initial development of the NTC database provided both trainers and doctrine developers with a much needed resource.

Once the data sources had been identified and explored as to content, an effort was made to develop short term studies to test the data sources. The immediate value to the Army was becoming apparent. Short-term studies included examining the effect of new equipment and organizations to determine the effectiveness of the new developments in simulated environment.

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[1]For a more detailed description of the development of data sources, see Chap. 3 "Data Sources & Development".

Table 1. Data Available to Analysts in 1988.

INGRES Digital Data: This NTC digital database was derived from both the CIS log and RDMS log digital data. The database consisted 19 mission-level INGRES tables and the event driven data captured during the engagement training exercises.
CONTOUR AND PLAYER LOCATION PLOTS: Printouts illustrated the elevation contours and player locations at a specified time during the battle. These were derived from the digital database in conjunction with plots developed on the VAX computer.
DEANZA GRAPHICS DISPLAY AND VT125 DATA DISPLAY: Digitally recorded battle playback and information about the events as they occurred could be obtained through the DeAnza Replay Stations.
GENERAL-PURPOSE NTC ANALYSIS OF TRAINING TOOL: A software tool developed at ARI-POM allowed player movement and engagements to be viewed and analyzed on any IBM PC or compatible computer.
TAKE HOME PACKAGES: Feedback to the units by BOS by Co/Tm and Task Force were documented along with some battle statistics.
COMMUNICATIONS: All radio communications were recorded and stored on tape.
VIDEO AFTER ACTION REVIEWS: AAR video recordings were available for Task Force, company/team, platoon, Fire Support Battalion, Field Artillery, and Live Fire missions.
INITIALIZATION FILE: A hard copy document with information on instrumented unit and player listings, primarily used by database managers to correlate RDMS data with CIS data.
OPERATIONS ORDERS: Documents which described the scenarios developed for unit training at the NTC.
COMBINED ARMS ASSESSMENT TEAM REPORTS: Contained summary reports of SME observations during NTC Focused Rotations.
STANDING OPERATING PROCEDURE: Administrative, logistical, and training procedures used for combat processes were available.
NTC RULES OF ENGAGEMENT: A document which contained the basic guidelines for the ESX and LFX training at the NTC. The ROE applied to both the OPFOR and visiting units.
DAILY STAFF JOURNALS: Unit logs of activities by time and event kept by operators at each unit.
UNIT AFTER ACTION REPORTS: Hard copy reports were generated by units and included a summary of their perceptions of training events and unit performance.

Nichols (1986) at ARI-POM conducted a study using the THPs as a data source. She analyzed the efficacy of the H-Series as opposed to the J-Series MTOE, overall unit performance, and mission performance of Armor versus Mechanized Task Forces (TF) during Force-on-Force simulated battle. This study demonstrated the utility as well as the shortcomings of THPs as a data source. THPs were found to be reliable, but limited since they contained only macro level type variables. The study reported an advantage by the Mechanized TF under the J-Series. This advantage was demonstrated only during offensive engagements. The Armored TFs showed only minimal advantage during either defensive or offensive missions under the J-Series. While these results were useful, a broader, more comprehensive data source was required to determine the cause or reasons for these differences. The results of this study prompted the exploration on the digital data to explain the findings. Hence, the concept of a multi-step research effort was developed (Nichols, 1986).

Root (1986) used all available data sources and compiled an analysis on one mission for one TF. The report demonstrated the ability of the combined NTC data sources to provide a complete picture of battlefield events. Root conducted an analysis of a deliberate attack using data from the VAX Digital Tape Extract derived from the instrumented data which presented the positions of Co/Tms graphically at the critical time of the mission. The DeAnza Extracts, which were selected photographs of the ongoing battlefield events, showed the movement of the TF during the mission at the critical moments. THP information was used to clarify the particular details only accessible through direct observation of the OCs. THPs also provided information such as Battle Damage Assessment (BDA) and the planning and preparation activities which occurred before the execution of the mission. The Communications Tapes were listened to and presented in written form for the analysis. The Communications Tapes provided insight regarding the erroneous firing of artillery which revealed the error was a transposition of numbers. The Communications Tapes also demonstrated the confusion on the battlefield and within the TOC, and the poor reporting by subordinates. Although time consuming, this effort demonstrated the detailed insight available from the NTC database which could facilitate home-station training. Since the missions conducted at the NTC are fairly uniform from rotation to rotation, conducting an in-depth analysis over time could provide indicators of systemic problems for Army wide lessons learned.

Heretofore lessons learned were generated primarily by senior staff officers and chiefs of operations upon their departure from NTC. The issues they addressed were derived subjectively, although expertly. One potential use of the enormous amounts of data that were arriving was to develop a method to derive issues systematically and objectively. Ritenour (1986) reviewed the two primary feedback sources, THPs and AARs, and compiled an issues document. He extracted systematically those comments made in the THPs and AARs which were repeated over time. He organized these comments by Battlefield Operating Systems (BOS), which was the rubric used by OCs during the conduct of AARs. Roughly 315 issues were identified which could be examined with the NTC data generated at that time. Although the list of issues was not exhaustive nor perhaps comprehensive, the study demonstrated how the NTC data could be used by the Army to focus derivation of lessons learned.

In addition to the verification of the importance of the NTC data to the Army through the

conduct of these early studies, ARI-POM began developing a methodology for measuring unit combat effectiveness at the NTC (Forsythe, 1986). The Army had long intended to assess combat effectiveness during peacetime in order to improve training and doctrine. The Army was also very interested in obtaining feedback on equipment, manning and organizational structure. While the NTC database provided great quantities of data, an analytical framework, or model, was required to direct the data collection and analysis efforts. A methodology was developed to provide the research community with the information it required to assess unit performance and to provide a link between NTC results and home station training. Mission critical events were explored to determine how they could be observed, and how events could be recorded and analyzed through standards of performance, measures of performance, and measures of effectiveness. This effort resulted in a systematic approach to measure performance and potentially permitted a more integrated and comprehensive consideration of variables which systematically affect unit performance. The accomplishment of specific tactical missions was the focus, not the accomplishment of voluminous AMTPs. By establishing mission effectiveness criteria, the identification of strengths and weaknesses could be identified over time and provide both unit specific and Army-wide lessons regarding training, doctrine, equipment and organization. By providing a method and ultimately a tool which wed both the scientific and military priorities through this focus on performance-data gathering, meaningful and objective lessons learned could be provided. This study and those that spun from it provided tools to derive institutional lessons learned from the NTC (as addressed in the 1986 GAO letter).

Two major ARI projects confirmed the feasibility and value of unit performance measurement of combat units at a CTC and revealed limitations of the CTC Archive. The first was a study which demonstrated the positive correlation between operating tempo (OPTEMPO) as measured by the annualized tank mileage employed by units prior to their rotation and performance at NTC as measured by casualty/exchange ratios (Hiller, McFann, & Lehowicz, 1990). The data set for NTC performance was extensive: 100 missions, during 16 rotations, by units from five installations. A set that extensive was stable enough to determine the relationship between OPTEMPO and unit performance capability. The results were cited by the Secretary of Defense and used to defend the Army training budget.

The second project to consider performance at a CTC was Project Determinants (Holz, O'Mara, & Keesling, 1994). This project studied seven rotations and assessed the success of each mission. Since there was no credible measure of success that could be applied for each mission, ARI researchers coordinated with NTC OCs for tailored direct assessments. The Archive was a resource to identify recurring problems and to determine the scope of available data. The results confirmed Army training doctrine in general and the previous OPTEMPO findings. In addition, ARI researchers were able to use NTC data to address issues related to leadership, cohesion, and individual characteristics. Like the OPTEMPO project, Determinants confirmed the feasibility and usefulness of unit performance measurement of combat units at NTC.

By 1987, ARI-POM was producing substantive and systematic reports on all the topics

described in the LOA[2]. The following is an excerpt of the studies conducted at this time. The topics covered are noteworthy; these studies addressed doctrine, equipment, organization, and combat effectiveness using the NTC generated data (See Table 2.). The conduct of these studies demonstrated the utility of the NTC data, as well as the ability to provide information to the Army so that it could begin to meet the mission of deriving Lessons learned from the NTC.

Table 2. Extract of Initial Studies

National Training Center Mortar Fire Support: Relationship to Training Doctrine. Hamza & Williams , 1986.
NTC Performance Trends for the Maneuver Operating System: Relationship to Training Doctrine. Johnson , 1986.
A Survey Comparing the M2/M3 Bradley Fighting Vehicle and the M113 Armored Personnel Carrier by Members of the NTC Operations Group and OPFOR. Hamza, 1986.
Direct Fire Fratricides at the National Training Center. Hamza & Banks, 1987.
Commander Survivability at the National Training Center. Doherty & Atwood, 1987.
Commander Survivability at the National Training Center. Zimmerman, Brosemer, & Hamza, 1987.
Comparison of the BFVs and M113 Equipped Battalion Task Forces on Live Fire Performance at the NTC. Doherty & Hiller , 1987.
An NTC Live Fire Performance Analysis. Forsythe & Doherty, 1987.
A Preliminary Analysis of NTC Force-on-Force Performance. Nichols, 1987.
A Method of Analysis for the Bradley Fighting Vehicle System. Shackelford, 1987.
Trendline Analysis of Direct Fire at the National Training Center. Zimmerman, 1987.

During this initial period, ARI-POM conducted three directions of research all pertaining to the exploitation and full realization of the NTC data. The research conducted consisted of : a) methodological research to organize and analyze training data, b) analytical research on high priority training issues in support of CALL, c) applied research to develop products for use within the Army training environment (Lewman, Zimmerman, Briscoe, Root, & Allan, 1988). In 1988, ARI-POM began producing regular trendlines for CALL lessons learned. The method used was systematic and derived from all the data sources available. While the initial reports were in response to immediate Army concerns and demonstrative of the ability to derive lessons learned, later studies and reports demonstrated the capability to derive long-term, institutional Lessons learned. While reports and instruments were developed in this initial time period, an extensive effort was made to provide military analysts access to the data (Lewman, 1988).

In 1988, Colonel Kent Harrison was commander of CALL, newly instituted. His job was to create "an agency for change". He formulated working groups to analyze, collect, and process

[2] See Appendix A for a Bibliography of studies derived from the CTC-Archive.

the data generated at the CTCs to provide input into Doctrine, Training, Organization, Leadership, Materiel, and Soldiers (DTOLMS). Initially, the groups began identifying issues using the CTC Archive. Whenever an issue or problem continued over time and over units (i.e., occurred 8 times or more), it was identified as a possible "item". These items were then compiled into a huge laundry list of potential lessons learned and submitted to CAC leaders and the relevant proponents. The proponents then selected those items which seemed the most important to them. Solutions were created by the proponents and implemented into one or more units. When the units rotated to a CTC, they underwent a 'focused' rotation which examined the efficacy of the change. The cycle from submitting the items to the implementation of a solution was termed an Action Plan. Hence, the cycle became:

1. Identify issues by examining CTC Archive Data.
2. Submit issues to CAC leaders & proponents.
3. Identify issue(s) for action.
4. Derive solution(s).
5. Implement solution(s) at home station training.
6. Conduct focused rotation to examine efficacy of solutions.
7. Implement change throughout the Army or derive another solution.

An example is the issue of fratricide. Units rotating through the CTCs consistently had high fratricide rates. When the issue was submitted to the schools and proponents, they realized that units trained with only US targets. Enemy and US targets were then introduced together so that units would have to discriminate between the two at home station. During the focused rotation on fratricide, units which trained with enemy and US targets had fewer fratricides. Now units regularly train with both US and enemy targets.

CHAPTER III
TRADOC STUDIES

A pivotal event in the transition of the archive from an R&D asset to an operational resource was a directive by General Thurman, TRADOC Commander, for "a structured exploitation of the NTC database resident at ARI-POM." An instructional period was required to familiarize military analysts with the NTC Archive capability and tools before the database could be used. ARI-POM developed training manuals and an instruction course to help the analysts derive the information they required. Certification of users also helped to restrict access. This led to a series of seven one-week combined arms workshops involving 90 people from 10 schools and centers. Each workshop included several branches. For example, the Armor workshop was supported by personnel from the Infantry, Field Artillery, Engineer, and MI Schools. ARI-POM conducted a prototype workshop in February 1988 and then hosted the combined arms workshops from March to June of that year.

The lead school or integrating center developed issues to be addressed before each workshop and CALL reviewed the issues with ARI and NTC for feasibility. The first day of the workshop was devoted to training on the archive. The scope included an overview of the CTCs, discussion of issues of data security and workshop objectives, a description of data sources with a discussion of strengths and weaknesses, a sample case study, and a practical exercise that required participants to execute a query for the instrumented data. Participants then spent the remainder of the week conducting research specific to the issues developed by the lead agency. ARI scientists, contractor personnel, and CATA/CALL staff assisted with the research phase.

At the end of the week, each team presented a briefing on their results to the commandant of the lead school or center. The issues addressed are summarized in Table 3. In some cases the issues listed are representative of a longer list. All agencies also commented on the strengths and weaknesses of the data, and recommended additional information to be collected.

Each proponent attending the workshop then presented the results in a briefing to General Thurman in June 1988. All proponents considered the archive to be valuable despite gaps in information and the difficulty of accessing some of the data (most frequently digital data and communications tapes). The CAC presentation at this briefing presented a plan to move the CTC Archive to Fort Leavenworth.

Beginning in August 1988, the workshops were scheduled on a quarterly basis. Completion of the training was a pre-requisite for access to information in the archive. The one-day structured training on the archive continued (the practical exercise was the basis for certification), but briefings of research projects were not required. Much of the impetus in the first three quarterly workshops were efforts to augment findings for an update briefing to General Thurman in May 1989.

Table 3. Issues Addressed During CTC Archive Workshops.

Agency	Selected Issues Addressed
Infantry School	• Contributions of Echo Company • Reconnaissance requirements/capabilities at TF/Bde • Contributions of mortars • Mine clearing effectiveness • Effectiveness of decision making process • Logistics • Adequacy of graphic aids
Armor School	• Relationship of tank battle participation with OPFOR/BLUEFOR loss ratio • Relationship between number and quality of survivability positions and friendly force survival • Synchronization of CAS, attack helicopters, artillery, obstacles, and direct fire
Engineer School	• Adequacy of breaching doctrine • Defensive frontages • Number of survivability positions • Fratricide from friendly minefields • Quality of obstacles and survivability positions
Field Artillery School	• Rehearsal of fire plan • Fire support execution matrix • Location of TF FSO • Understanding of commander's intent • Length of target list • Massing of fires
Intel School	• S2 role in staff planning/wargaming process • Reconnaissance and surveillance • Conterreconnnaissance/Countersurveillance • Reporting: Combat information; dissemination of intelligence • GSR employment • MI Co team operations (influence of MI unit support)
ADA School	• Impact of ADA on freedom to maneuver and survivability • Effectiveness and impact of early warning
Aviation School	• Aviation IPB • Aviation unit battlefield movement • Attack helicopter engagement techniques
Logistics Center	• Conclusions on doctrine, training, organization, and materiel: - Arm - Fuel - Fix (Maintain, Class IX, Recover/Evacuate) - Sustain (Class I, Medical, FSB)
Signal School	• Signal planning and preparation • Information flow
Soldier Support Center	• Operational planning • Reporting • Mutual support between S1 and S4

As the emphasis from TRADOC waned, the quantity and quality of research conducted by military analysts decreased. The CALL and ARI representatives responsible for the training concluded that the limited structure did not lead participants to master enough of the archive tools to receive maximum benefit from the training. However, the workshops continued to be offered on a quarterly basis with fair attendance from the various schools and military branches.

CHAPTER IV
CTC DATA ACCESS DEVELOPMENT

Two additional Combat Training Centers (CTC) were established from 1987 to 1989; the Joint Regional Training Center (JRTC) at Fort Chaffee, Arkansas and the Combat Maneuver Training Center (CMTC) at Hohenfels Training Area in the Federal Republic of Germany. The data produced at these CTCs were reviewed, catalogued and incorporated into the NTC database (Nichols, 1988; Lewman, Zimmerman, Briscoe, Root, Allan & Shillcock, 1989). Though each of the CTCs had a different institutional focus (e.g., collective training for mid to heavy intensity combat training at NTC, low intensity combat training at JRTC), assessment and feedback mechanisms were generally comparable for all. Performance measurement, based on Army doctrine, was conducted by the OCs at all the CTCs and presented in AARs and THPs. Once these CTCs were operational, ARI-POM investigated their data production and formats to determine how these data could be integrated into the CTC Archive (Nichols, 1989). Collection and processing requirements were identified and met. The composition and types of the data generated at the CTCs varied from CTC to CTC (See Table 4.). The dynamic nature of the CTCs such as the frequent changes to rules of engagement, training scenarios, and unit performance measurements required the CTC Archive be flexible and dynamic as well. While ARI-POM staff sought to maintain flexibility, a tremendous effort was made to integrate the various data into a useable database. At this point the NTC Archive became the CTC Archive. In response to these additional data sources, ARI-POM designed an objective data collection system.

The volume of data which began arriving at this time was staggering. Combined, there were 33 rotations each year at the CTCs. One CTC rotation could produce 3,500 pieces of paper (THPs, overlays, etc.), 200 video tapes, 10-50 floppy disks, 10-35 audio tapes, and extensive digital data (e.g., battlefield replay, event logs). A system of integrating and presenting the data was created. The data also arrived in various formats such as: computer data tapes containing instrumented data from the NTC, versus diskettes from the JRTC containing I-MILES data; text data on diskette, primarily THPs from the NTC and JRTC, versus hard copy THPs from the CMTC; various paper data from all the CTCs (e.g., maps, overlays, charts); AAR video tapes were sent from all CTCs; 40-track audio tapes from the NTC and CMTC; and, T&EO data from the JRTC in SPSS-PC format on diskette. Of these data sources, Nichols (1990) reported that the JRTC submitted T&EO hard copy data, not digital data. While the CMTC collected T&EO data, it did not systematically send this data to the archive. The primary data sources used were the replay and mission databases, followed by the paper copy of THPs. Graphics and AAR videos were accessed to a much lesser degree (5% of the studies conducted up to 1990).

Table 4. CTC Data Sources (Adapted from Lewman, et al., 1992).

SOURCES OF CTC DATA	NTC	JRTC	CMTC
Take Home Packages	✓	✓	✓
After Action Reviews	✓	✓	✓
Operations Orders/Plans	✓	✓	✓
Map Overlays	✓	✓	✓
Operation Logs	✓	✓	✓
Observer Controller Logs		✓	✓
Communications Tapes	✓		✓
T&EO Checklists		✓	✓
Firing Events	✓	✓	
Casualty Information	✓	✓	✓
Player Position Location	✓		
Player/Vehicle/Weapons Status	✓		

During this time (1989-90) the NTC upgraded the instrumentation capability to track more players on the battlefield. The new system could track up to 2,000 players as opposed to the previous 500. The software was also rewritten which compelled ARI-POM to rewrite all the software to access the instrumented data. The resulting database was much more comprehensive

and reliable (Baldwin, 1995[3]).

During the next five years, ARI-POM developed and implemented a Training Research Automated Catalog System (TRACS) which listed CTC data sources in a single database and provided both an operator and user interface capability (Lewman, et. al, 1989). TRACS simplified the analyst's work to determine what data were available for a particular study. TRACS provided summary data, a catalog of data sources, and data locations. From this information an analyst could automatically determine which rotations had the data of interest and access the improved CTC digital databases (Briscoe, 1990).

TRACS was a menu-driven catalog of the data available in the CTC Archive. To use TRACS, the user determined a research issue to pursue and then determined the selection criteria to support the research. The menu-driven TRACS system guided the user through a series of steps by which to sample missions for analysis. For example, if an analyst was interested in how units were performing during a counter attack mission since the addition of a new weapon system, the analyst would select the mission type (e.g., counter attack) and rotations (e.g., 87-07) which followed the addition of the new weapon system.

Several programs were created to facilitate analysis of the data and provide analysts tools with which to access the types of information required (See Table 5). These tools were available through the use of PCS which meant analysts could access and process the data from remote locations.

Table 5. Programs & Tools for PCs.

TASK FORCE BATTLE TRACE (TBAT) Provided snapshots of the battle flow.
THE MISSION PERFORMANCE ANALYSIS REPLAY TOOL (MPART) Graphically portrayed NTC battles in a real-time event flow.
GENERAL PURPOSE NTC ANALYSIS OF TRAINING TOOl (GNATT II). Permitted analysts to replay NTC training missions on any MS-DOS computer.
GRAPHICS DATABASE Graphics previously only available in paper copy.

The Combat Operations Research Facility (CORF) was conceived and implemented at ARI-POM to facilitate research by both military and research analysts. The CORF included digital data and hard-copy products. Later, in 1991, a Battle Damage Assessment Database (BDA) which contained BDA statistics on a mission by mission basis was added. The BDA database was derived from the THPs.

By October of 1990, ARI-POM had developed the Combat Analysts' Workstation (CAW).

[3] Personal communication September 1995.

This was a digital system that enabled analysts to access data from a personal computer. The CAW was created based on a government furnished Intelligent Gateway Processor (IGP) software, developed by Lawrence Livermore Laboratory. The mechanism used to integrate and facilitate the use of the available databases was the Combat Training Data Gateway (CTDG) developed by ARI-POM (Briscoe, 1991). CTDG was a PC-based bulletin board system which provided remote access to TRACS, other VAX-based databases, mission replay files, and graphics files (Briscoe, 1991). As TRACS developed it became known as the Automated Finder's Guide (Mulshine & Murphy, 1994). A guide to train and assist analysts in the operation of the CAW and CORF was written and produced (Nichols & Shillcock, 1990). The CAW was designed to allow Army analysts remote access from anywhere in the world to a variety of CTC data.

Training on the archive tools was the principal means for making the data available to Army personnel. The CAW was a user-friendly system, but required training and certification for purposes of accessing the data. In December 1992 ARI expanded the workshop to two weeks to cover all archive tools and the research process. To support this expansion, CAC developed an extensive research facility at POM that included 16 CAWs. The workshop was designed to have two phases: a) development of skills to extract data relevant to an issue; and, b) conduct of research and preparation of a briefing on the issue.

The phase on development of skills followed the Mager Criterion-Referenced Training (CRT) Model. In accordance with that model, training proceeded by module. Each module included a skills assessment, a series of practical exercises with text to prepare participants for the skills assessment, and feedback on the skills assessment. Participants worked through the modules at their own pace, assisted by facilitators from ARI and supporting contractors. The module on preparing a research plan culminated with a small group meeting where each participant described the planned research approach.

The bulk of the two weeks was devoted to independent research on the issues. ARI and contractors assisted with detailed data requests and data analysis. At the end of the second week, each participant presented the results of his or her research in a briefing. The briefing was the basis for certification to use the archive. The reports that were suitable for CALL to certify the researcher are included in Table 6.

A 1993 briefing by CALL (Wolff) identified 35 studies and products within TRADOC to illustrate the value of the CTC Archive. In addition, 28 studies were completed during the two-week CTC Archive Training Course. The 63 resulting studies and products are summarized by DTOML in Table 7. The agencies labeled "Other" in that table include government agencies and civilian research corporations.

Table 6. Issues by DTOML for TRADOC Schools and Centers and Other Organizations.

DTOML	School or Center	Issue
Doctrine	CAC	Logistics on the battlefield Employment of recon units in defense*[4]
	Armor	Battalion level attacks on two axes Heavy/Light employment in the desert
	Infantry	Light infantry doctrine & training
	Aviation	AH64 & OH58 employment on the battlefield
	Engineer	Combined arms breaching operations Brigade level obstacle synchronization
	Intel	GSR employment MI and company team operations Quality of R&S/counter-recon plan* Contributions of IEW activities*
	CASCOM	Effectiveness of BSA defense
	MP	Use of MPs in assessing BCC and rear operations
	Chemical	Use of NBC and its impact on the mission
	Chaplain	Factors that contribute to Bde Ministry Team effectiveness* Doctrinal training and employment of chaplains
	Soldier Support Center	Effectiveness of Bn TF CTCP*
	Other	Impact of smoke and obscurants on M/CM/S BOS*

[4]Asterisk indicates study was developed during two-week CTC Archive Training Course.

Table 6. Cont'd

DTOML	School or Center	Issue
Training	CAC	Breaching operations Reconnaissance RC brigades during preparation for Desert Storm* C&GS POI update (AAR)
	Armor	Upgrade of POI
	Infantry	Mortars and antiarmor at JRTC
	Artillery Intel	Firing rates and effects at the NTC Integration of mortars* Reconnaissance and surveillance Upgrade of POI
	AHS	Training trends of medical staff at brigade and battalion Medical training problems
	MP	Trends in MP platoon operations*
	Other	AD early warning effectiveness* Impact of early NTC missions on late missions for RC and AC units*
Organization	CAC	Artillery organization (battery vs. platoon) pre- and post-Gulf War*
	Armor	Scout force composition
	JFK Spec. Warfare	Link-up between special operation forces and maneuver elements*
Materiel	Armor	Vulnerability of scout vehicles: APC, BFV, and HMMWV*
	Infantry	IFV requirements and performance at NTC ITV and TOW performance Lethality and survivability of E Co. M2 and ITV*
	Intel	Automation of brigade S2 intel preparation using sensors at EAB*
	CASCOM	Refueling on the move Logistics automation use and requisition flow

Table 6 Cont'd

Materiel con'td	Signal	Radio net benchmarking Communications procedures and equipment*
	Other	Comparison of M60A3-M113 units and M1-M113 units*
Leadership	CAC	Casualty evacuation Fratricide Relation between brigade rehearsal techniques and synchronization* Impact of DST in defense*
	Armor	Impact of DST in offense*
	Infantry	Staff force planning and integration
	Engineer	Impact of rehearsals on performance
	Artillery	ID problems of FSO*
	Intel	Staff planning and reporting
	AHS	Casualty rates Causes of died-of-wounds casualties
	Other	Impact of command and control* Fratricide rates by type of mission, weapon, and time of day for Armor* RC fire support planning* Fratricide rate: OPFOR and BLUEFOR* CAS integration*

In June 1994 the scope of the workshop was reduced to a one-week course on skills development to extract data. During that workshop, participants were also trained in procedures to access data through a modem connection. The concept was that they would complete their research using the remote procedures at their home installation with certification based on the reported results to CALL. The certified participants would then conduct the workshop at their location using training materials focussed on extracting data via modem.

The materials to support the remote workshop were finalized after the June 1994 on-site workshop. The ARI monitor (Hamza) validated those materials through a workshop at the U.S. Military Academy, West Point, NY. No other organization conducted a remote workshop.

The number of people who received training on the archive at POM is summarized in Table 7. Since access to the data was contingent on completing the workshop, the summary of participants is a rough indicator of interest in the CTC Archive data.

About two-thirds of the participants came from TRADOC. Such a distribution is understandable since CAC was proponent for the archive in general and the workshop in particular. The type of agency most likely to seek access to the archive was a TRADOC school or center, spurred largely by General Thurman's directive. Seventeen schools or centers sent members of their faculty and staff to be trained at the archive due to General Thurman's directive.

Among government research development test and evaluation agencies, the Army Research Institute had the highest number of people attending the workshop. "Other" government agencies included Operational Test and Evaluation Center (Army and Air Force), Livermore Laboratories, Diamond Laboratories, Concepts Analysis Agency, Defense Institute for Training Resources Analyses, and Defense Advanced Research Projects Agency. Fourteen civilian corporations sent staff members to the archive training. Corporations with more than one participant were BDM, PRC, HumRRO, Rand, MPRI, and Litton. Participants from FORSCOM came from FORSCOM HQ, 7th ID(L), and a CTC engineer company. The "Other" organization types include USAREUR and 7th Army, Special Operations Command, National Security Agency, Information Systems Command, U.S. Military Academy, and the National Guard Bureau.

Table 7. Summary of Workshop Participants.

Type of Organization	Initial Workshop	CRT Workshop	Total
TRADOC			323
Schools	184	23	
CAC	43	6	
TRAC	30	3	
CTC	27	2	
HQ	5	0	
Government RDT&E			76
ARI	42	7	
Naval Post-Grad School	17	0	
Other	8	2	
Civilian R&D	29	11	40
Army Materiel Command	5	4	9
FORSCOM	7	0	7
Corp of Engineers	6	0	6
Other	12	5	17
Total	415	63	478

CHAPTER V
DATA SOURCES AND ARCHIVE TOOLS

The following is a description of the various data sources, evolution of the data, and the data processing undertaken. In the beginning stages, since the data sources were not collected for the purposes of analysis but were products generated for training, the data were examined for utility and accessibility to researchers. Although the data sources were perhaps incomplete, early studies revealed the unprecedented resource these data potentially provided to the Army.

Early data sources primarily consisted of data generated by the instrumentation system and data collected by human observers (i.e., OCs) (Banks, 1993). The data sources primarily accessed by analysts were the digital data and the THPs. The data sources had not changed dramatically until 1995 when the THPs were extensively streamlined. Additional types of data were received with the implementation of JRTC and CMTC. The capability to analyze and obtain meaningful information from the data changed substantially from 1985 to 1995. The following is a review of the data sources sent to ARI-POM and the evolutions they underwent (Baldwin 1994; Briscoe & Kemper, 1986, Kemper, 1986; Ford & Hamza 1992; Hutton 1994; Keesling, 1995; Nichols,1990; Whitmarsh, 1987; Zimmerman, Nichols, & Kemper, 1986).

Instrumented Data

Although initially fraught with difficulty and breakdowns, the digital information from the NTC would become the predominant data source utilized at the CTC Archive. The data were not available for use until substantial programming and compiling had been completed. By the time the CTC Archive was transferred to Ft. Leavenworth, it included a replay program of battlefield events, a computerized catalogue of all data available at the CTC Archive, CTC performance information, automated THPs, and statistical information derived from the CTCs' instrumentation systems.

The NTC Instrumented System (NTC-IS) consisted of four subsystems: the Range Data Measurement Subsystem (RDMS), Range Monitoring and Control Subsystem (RMCS), Core Instrumentation Subsystem (CIS), and the Live Fire Subsystem (LFS). The RDMS and CIS contained the primary digital data collected at the NTC (Briscoe, 1986; Whitmarsh, 1987).

The RDMS collected the raw field data pertaining to 'real-time' position/location and engagement event data on all players equipped with telemetry instrumentation during training with the Multiple Integrated Laser Engagement System (MILES). Real-time data is characterized by being collected immediately as the event occurs. The CIS provided all 'real-time' data processing and interactive play capabilities needed to monitor, command, and control all engagement simulations which was manually input into the NTC-IS. The RMCS monitored and controlled all activities on engagement simulations and derived data from the RDMS and CIS systems (Briscoe, 1986; Whitmarsh, 1987). The LFS derived data from the CIS and RDMS subsystems (Briscoe, 1986).

The NTC-IS Data Tape contained battle replay information for display on NTC workstation graphic terminals. This data was termed NTC History Data. The data in these files were generated from the field instrumentation system and operator-entered interactive command and control inputs. The field instrumentated data were captured via transmission from digital posts at various points on the battlefield. The interactive command and control inputs were conducted at the TAF where OCs could call in information and "kill" players. Input of indirect fire simulated kills was also conducted at the TAF (SAI, 1984).

ARI-POM conducted an extensive study to examine the NTC data collection systems and the existing database to ascertain accessibility and utility for ARI and Army research. This study investigated the format and character of the NTC data which resulted in a detailed documentation of the two NTC digital data sources, the log tapes from the RDMS and back up files from the CIS (Fobes, 1984).

Instrumented raw data consisted of information on player position, direct fire weapons events, and communications. Player position measurements were continuously updated every 60 seconds, except for those "killed". Weapon events for direct fire weapon simulators were divided into two categories: a) a firing event when a weapon was fired, and b) a kill. Kills were "paired" with weapon effect events to assign a target to a weapon for computing player performance statistics. Indirect fire kills and minefield event kills were OC generated and manually input into the database. Communications were recorded for every depression-release conducted by a radio operator. The transmission time and number of transmissions made were computed.

The NTC-IS archived player position, weapon and communications event data, OC observations, alert messages (e.g., controller gun events, indirect-fire firings, weapon-target pairings) and free format manually input messages. These data were stored in a Player History File (PHF) for each exercise segment. Segments were discrete portions of the overall Electronically Simulated (ES) or Live Fire (LF) exercise and delineated by natural breaks in the engagement, a transition between tactical missions, movement to a new terrain area, a major change in environmental conditions, or by a command decision. These segments lasted up to 48 hours, but generally lasted 8 to 12 hours (Fobes, 1984).

The RDMS provided real time player position location and engagement event data on all instrumented players.

The RMCS provided the means to monitor and control activity on the ES and LF ranges. The capabilities included automated and human sensors and a communications component to connect these sensors together and with the CIS. The CIS provided real time data processing and display capabilities required to monitor, command and control the Engagement Simulation (ES) and Live Fire (LF) exercise activities. The CIS also provided the data processing capabilities required to synthesize and present near real-time AAR and THPs. CIS also provided the data processing and display capabilities required to support Training Developments and Combat Developments research with NTC data.

The CIS Log consisted of initialization data, player/unit update information, RDMS event messages, firer-target pairings, position/location (PL), control measures, and indirect fire casualty assessments (IFCAS). This data usually arrived on 5-10 magnetic tapes per task force per rotation, contained 15-30 mission segments per task force, 4 global files per task force, and 9-12 mission specific files. CIS log provided data for the NTC Database Research System (NTCDRS) and the NTC Workstations. Unlike all other data sources, this information was available for all NTC rotations. This important factor prompted to researchers to examine CIS Logs very closely.

The NTCDRS was a system developed by SAI to convert the log tapes generated on the CIS into a form which would facilitate analysis (SAI, Final Report, 1984). The taped data were formatted for the INGRES Relational data base management system (RDBMS) on the DEC-VAX 11/780 computing system. INGRES was selected based on the research database (RDB) criteria which were to maximize data element correlations, be user friendly, be retrieval efficient and modularly expandable. It was also to allow researchers reliable information and meet computer system specifications. This system was implemented as a series of computer programs which produced a series of relational database tables. These tables were to be used to derive reports and rudimentary statistics. INGRES provided information for research by manipulating the existing 61 data tables.

However, there were major flaws with this software program; the primary one being that only one mission at a time could be examined or retrieved, hence there was no capability to build a large enough database to actually derive anything more than immediate data.

The RDMS Log contained all data passed from the RDMS to the CIS such as field events including MILES, player position/location, and status messages for the RDMS components. While some of the raw data were systematically transferred to the CIS, other data remained solely on the RDMS log tapes, such as the result (HIT, NEAR MISS, or KILL) paired with weapon type. This information was input from the the Position Tracking Computational Component (PTCC) of the RDMS and required CIS initialization information to be useful. RDMS Logs occupied a series of 15-30 magnetic tapes per rotation. Though a valuable source of information and an important contributor to the NTCDRS, the RDMS Log data was not organized by task force or mission and was not available for all NTC rotations (Briscoe, 1986).

The RDMS tapes were compared to the CIS tapes and a strong correlation was found (Briscoe, 1986). Software was then developed to process the RDMS log data and to incorporate this data into the redesigned database, thus supplementing the CIS data.

Once the instrumented data began arriving at ARI-POM an examination was made regarding the reliability of the data. The data were indeed skewed due to instrumentation difficulties, such as noninstrumented vehicles, weapons, and personnel; equipment failure; terrain masking; pairing errors of killer weapon to vehicle killed; and software problems. Additionally, the capability to support systematic analyses was limited because of the following reasons (Banks & Whitmarsh, 1987; Briscoe, 1986; Doherty, 1987):

1. The programming was such that only one set of data, one mission, could be retrieved. The software 'hard-coded' the resulting database named as ARIDATA. The result was that each time a mission was retrieved, the previous mission database was erased or written over. This precluded any ability to build a database from which to derive long term or even rotational lessons learned.
2. The software system was prone to catastrophic failure at several junctions.
3. The system was operated through a number of command files which were badly documented, awkward to use, and error-producing.
4. The NTCDRS databases could support only a small percentage of the research efforts because the database was limited to the CIS digital data.
5. The data within the INGRES tables of NTCDRS were difficult to use, the queries required extensive time.
6. The NTCDRS database was unreliable because it contained multiple occurrences of identical data, and difficult to use data relations and keys.

ARI-POM then set about designing a database which would contain not only the digital data in an easy to use format, but also the hard-copy data needed to derive a complete picture of NTC rotations. The GAO letter of 1986 spoke of the need to design a database which facilitated research and was based on research requirements. Not since the inception of the NTC had any effort been made to address the needs of the research community. In response to these concerns, the redesign included the following:

1. Requirements Analysis. While the potential use of these data sources was great, the realization of this potential was deterred by the lack of information provided to the military and scientific community on what kind of data were available or how to properly interpret the data with all their limitations. Hence, ARI-POM solicited information from potential NTC data users about what they required. The Infantry School at Fort Benning, the Armor School at Fort Knox, and the CAC at Fort Leavenworth were contacted. Requirements such as data types, definitions, quality, units, etc. were included in this step. This effort was responsive to the GAO (1986) finding that the research community needed to be contacted for their input regarding data needs.
2. Database Structure Design. The table structures, data relations, and keys were defined. Complete specifications and documentation were made of all data sources, including format information and processes needed to incorporate the data into the database.
3. Processes. This phase concerned the development of processes by which to build the new databases. The processes included computer programs, command files, manual entry, data verification and the derivation of some data elements.
4. Implementation. All the separate entities developed in the previous steps were integrated and the NTCDRS format was retrofitted.

ARI-POM, undertook to correct the instrumented data problems with assistance from BDM. By September of 1985, the NTCDRS was operational. The database redesign was initiated by defining an approach culminating in a database system that supported the requirements of the Army

and ARI. Next, a preliminary design was published and distributed to all potential users of the NTC data identified at that time. Comments and suggestions were considered and incorporated through a modified Delphi technique into the final revision of the basic design, and development commenced. The database building software was completed in May, 1987, at which time mission databases were developed.

A more complete database was accomplished by writing a VAX FORTRAN program General Dynamics Electronics Tape (GDETAP) to read the GDE log tapes which contained the RDMS log information produced at the NTC. This program and use of this log was undertaken because the RDMS logs contained all the information passed to the CIS (NTCDRS), plus additional information which was not passed (Briscoe, 1986 (a)). After the completion of this project, approximately 30 utility programs and command files were developed to enable researchers to analyze the data. The systems needed by the analysts included reloading specific tables, documenting database contents, and dumping intermediate files. More than 500 mission segments were quickly processed by NTCDRS, which contained both the CIS and RDMS information, and were made available to researchers. This was the first time the digital data generated at the NTC provided information for researchers. Several studies were conducted using the improved database and useful information provided to the Army.[5] The RDMS log information also provided, once processed through the GDETAP program, a check and validation of the NTCDRS. The comparison of data yielded consistency between the two sources (Briscoe, 1986 (b)).

By 1988, ARI had identified 19 tables from the mission databases and had developed programs to extract the tables (McCluskey & Lewman, 1988) (See Table 8.). Three-hundred missions of data were loaded and available for research. Although awkward to manipulate, a system had been developed and the ability to conduct trend analysis was available. Programs with which to derive and build databases were developed and user manuals written (Baldwin, 1990).

[5]See Appendix A for a summary of studies conducted during this time period.

Table 8. 1988 Mission Databases.

Mission Databases Available by 1988
Mission Identification Table (MD)
Player State Initialization Table (PSIT)
Player State Update Table (PSUT)
Unit State Initialization Table (USIT)
Unit State Update Table (USUT)
Unit Type Table (UTT)
Player/Vehicle/Weapon Code Table (PVWT)
Firing Event Table (FET)
Pairing Event Table (PET)
Communication Table (CT)
Ground Player Position Location Table (GPLT)
Air Player Position Location Table (APLT)
IFCAS Target Table (IFTT)
IFCAS Target Group Table (IFGT)
IFCAS Missions Fired Table (IFMF)
IFCAS Casualties Table (IFCT)
Minefield Casualties Table (MCT)
Control Measure Table (CMT)
Control Measure Add Table (CMA)

Although the digital data had been deciphered and processed, Lewman's (1988) study indicated a redesign of the database was required for several reasons, they were:

1. The original design was inefficient because a great deal of redundant information was present in several tables;
2. This redundancy caused the databases to be inordinately wasteful of disk space, limiting the number of databases that could be maintained online at any particular time; and
3. The process required to build the databases was unwieldy, yet provided little or no opportunity to control the scope of the databases that were built.

Combat Analyst Workstation

The redesign included a digital system for analysts, termed the Combat Analysts' Workstation (CAW) (Nichols, 1990). This system provided access to the digital CTC Archive through a series of programs which were developed, tested, and implemented. The CAW was accessible from remote sites via a modem. The mechanism used to integrate and facilitate the use of the available databases was based on the Intelligent Gateway Processor (IGP) software, developed by Lawrence Livermore Laboratory. The Combat Training Data Gateway (CTDG) was adapted from the IGP (Rigg, 1990). The IGP was selected because it allows rapid, efficient, and

effective access to information without disturbing existing systems. CTDG was a PC-based bulletin board system which provided remote access to VAX-based databases, mission replay files, and graphics files (Briscoe, 1991; Rigg, 1990). CAC provided 14 of these workstations at ARI-POM. An interface system was developed and implemented termed the Training Research Automated Cataloging System (TRACS). TRACS provided users information regarding all data sources and access to the digital data processed at ARI-POM and a database located at Ft. Leavenworth, the Army Lessons Learned Management Information System (ALLMIS). ALLMIS provided textual lessons learned information and keyword selection capability (Briscoe, 1990; Nichols & Shillcock, 1991).

During this stage the Mission Databases integrated digital data from the JRTC IMILES system, player/unit descriptions, player position and events, definition of control measures by type and location, and indirect fire information. By 1991, over 450 NTC missions had been processed into the database along with the capability upgrade. A Mission Graphics Database provided the standard digitized images from each mission (Nichols & Shilcock, 1991). THPs were processed into the digital database to provide ready access. Battle replay capabilities continued to be refined.

In 1990 a proposed upgrade was implemented and completed at the NTC, which had been anticipated for 2 years. The upgrade entailed reconfiguring the entire system. The "SUN" was a technological advance which permitted the tracking of 2,000 plus players. This was an increase from the ability to track 400 players. The consequence, however, was that ARI-POM was required to re-write all the programming which had been accomplished in the first phase of the CTC Archive to retrieve the digital data. Once this was accomplished a new and much more detailed database emerged. The following tools were developed to assist analysts:

Task Force Battle Trace (TBAT) TBAT was designed to provide snapshots of the battle flow. This was accomplished by capturing all player movement during missions in a single picture presented with a realistic representation of the terrain. A pattern of movement could be derived and analyzed to determine maneuver and command and control performance.

The Mission Performance Analysis Replay Tool (MPART) MPART was designed to portray NTC battles in a real time event flow format graphically represented on a computer. MPART used terrain graphics with relief features and grid lines for orientation. The analyst could choose those individuals or collective groups of players for display according to need. Players were displayed by symbols which represented their respective combat systems (tank, APC, infantry). A key feature of MPART was the capability of using the METT-T templates to assist in mission analysis. The METT-T template could be moved and rotated to the proper position and orientation during the initial phase. At mission end, the number of players in each area of the template were automatically summarized as to kill, survived, etc.

General Purpose NTC Analysis of Training Tool (GNATT II) GNATT II was an evolution in replay programming which permitted analysts to replay NTC training missions on any MS-DOS computer suitably equipped with standard EGA color. In order to use this program, an analyst selected missions from the NTC Mission Databases on the VAX. The selected missions were then

copied from the VAX to diskette which were the data for the PC replay software. These replays could then be produced on the PC with the PC software. Numerous missions had been derived by ARI-POM, and were available on diskette. GNATT II was user-friendly and permitted analysts to do the following:

1. Display any area of the NTC from 2000 to less than 1 square kilometer.
2. Select any combination of players by unit designation.
3. Differentiate units and weapons systems by symbol type and color.
4. Display all types of battlefield graphics as desired.
5. Identify individual players using the mouse.
6. Identify killed players.
7. Graphically display MILES engagements.

Graphics Database ARI-POM had begun capturing graphics through video and pictures and reading this into the CTC digital database. The graphics listed below were available through the remote user's computer.

1. After Action Review Slides
2. Artillery Mission Logs
3. Artillery Preps
4. Artillery Mission Summary Sheets
5. Commander's Intent
6. Decision Support Templates
7. Event Templates
8. Execution Matrices
9. Firing Intensity Profiles
10. Fire Support Plans
11. Situational Templates
12. Obstacle Reports
13. Obstacle Plans.
14. Operations Orders
15. Operations Plans
16. Reconnaissance Plans
17. Reconnaissance & Surveillance Plans
18. Scout Positions.
19. Task Force Overlays
20. Mission Specific Graphics (a catch-all for previously undefined graphics peculiar to a mission)

Mission Database The Mission Database was a relational database which contained data derived for the CIS at the NTC. After the upgrade, CIS data were collected on SUN Work Stations and stored, as before, in real time format. The Mission Database was a collection of battle/mission research databases in which a separate research database was generated for each mission conducted at the NTC during a rotation. The separate databases contained direct fire event data, indirect fire

mission data, minefield data, communications data, ground and air player position location data, fratricide data, and maneuver control measure data (Walsh & Baldwin, 1995).

The year 1994 likewise saw another upgrade to the instrumentation, but this did not affect the collection of the digital information. There may be more data available, but at the writing of this report, this was unknown.

During the remainder of 1994 databases and interfaces were improved and data routinely processed. At the end of 1994, the end of the ARI-POM participation with the CTC Archive, the following databases were available (Baldwin, Bennett, Briscoe, & Mulshine, 1994; Mulshine, 1994 (a); Mulshine, 1994 (b); Mulshine, 1994 (c); Walsh & Baldwin, 1995):

Automated Finder's Guide (AFG). AFG was an improvement to Training Research Automated Catalog System (TRACS), but basically was the same system. TRACS and the AFG listed CTC data sources in a single database and provided both an operator and user interface capability (Lewman, et. al, 1989).

Automated THP Database. The Automated THP Database contained most of the textual data the CTCs sent to ARI-POM in the THPs. Files were derived and organized by BOS. The following rotations were available:

NTC: Rotations 90-01 to 94-05
JRTC: Rotations 90-01 to 94-09
CMTC: Rotations 90-01 to 94-02

Battle Damage Assessment (BDA) Database. BDA Database contained force-on-force battle statistics for each mission. These data were manually entered for NTC and CMTC. JRTC sometimes sent digitized BDA, which was then entered via the computer system. Not all CTC databases contain the same amount. The databases contained:

NTC: Rotations 90-01 through 90-11, 90-13, 91-02, 91-10, 91-12,
CMTC: Rotations 90-01 through 90-12, 91-01 through 91-10,
JRTC: Rotations 90-01 through 90-08, 91-01 through 91-09.

Take-Home Packages (THP)

THPs, a paper based data source, emerged early on as a reliable data source. THPs were developed for the units to take to home station and improve their training. The THPs included daily mission summaries, trend analyses across the seven Battlefield Operating Systems (BOS), VAAR, and summary statistics on casualty figures, equipment losses, and gunnery data. The THPs were primarily produced by transcribing OC comments and their subjective assessments. THPs varied widely in content and formation because no standard was enforced (Chapman, 1992; Nichols, 1987; Whitmarsh, 1987).

During the early years, THP statistics such as battle losses, casualties, battle loss ratios, radio transmissions, gunnery and battle damage assessments were calculated by hand by the OCs. Later, as the CIS became operational, these statistics were generated digitally. At the TAF, once the CIS was operational, analysts were able to further generate statistics and information for the THPs and AARs (Chapman, 1992; Shackelford, 1985). The information they contributed consisted of the above statistics as well as graphics generated by the DeAnza workstations which depicted critical times during mission execution.

The content of the packages evolved from 1982 to 1986 to include the TF Mission statement/Commander's concept, mission execution summary, battle statistics, review by BOS, and Field Manual focused observations (Nichols, 1987). The THP was prepared for each TF Commander by the NTC Training Analysis and Feedback (TAF) Division. The document contained narrative and numerical descriptions of unit performance at the NTC and recommendations for additional training at home station. THPs from 1986 to 1989 included (Kemper, 1986):

- •General Overview of the Purpose, Scope, and Organization of the THP
- •Summary description of the 14-day training, including missions conducted, equipment losses on both sides by mission, live-fire performance measures, and performance trends.
- •After Action Reviews (AARs) for each mission including:
  - -Narrative description
  - -Critical Events for each Operating System
  - -Statistical data on equipment losses and radio transmissions.
- •List of videotapes contained in the THP.

During fiscal 1987, THPs were further standardized by issuing forms to OCs which contained specific questions to be answered by all OCs for each mission. The THPs contained information on battle performance by BOS and by Co/Tm. This data collection system continued until 1995 (Yorther, 1995).

In 1990, Engineering and Economics Research, Inc. conducted a study of the THP and its utility at home station for the battalion commander. While the THP generally received approval, there were many areas of needed improvement noted. One of the more often cited criticisms was that the THP was received at home station approximately 3 months after a rotation, at which time training planning had already been initiated, much of the original force has been dispersed, and it became history rather than responsive to the training required. Generally, the THP was cited as a useful tool, though cumbersome and disjointed in focus (i.e., did not focus on METL, but on BOS) and provided no link between the OCs' analysis and AMTP training at home station. The content of the THP at that time was fairly consistent with the previous THPs.

In July 1993, the General Officer Steering Committee discussed the THPs being issued to home station from the NTC. They found that THPs were not timely nor responsive to the training needs of the units. The information contained in the THPs was deemed excessive and too costly. On 9 March 1995, LTC C. R. Hammond, CTC Director, and Major S.N. Welks, Chief of the

Operations Division of the CTCs, issued a FAX to all CTCs and other associated institutions with instructions for the implementation of a new format for THPs. The new THP format was extremely streamlined and included only the following: a) Commander's Final AAR, b) Executive Summary and BOS Analysis limited to 50 pages, c) Battle Summary Video Tapes, d) maps, graphics, and charts, and e) Tailored Information for the Unit Command on request. No further guidance was given. Each OC team at each of the CTCs was free to develop the THPs within these restrictions (Maj. Yother, 1995). The NTC decided to drop the AAR information by Co/Tm and began including only the TF by BOS analyses at the end of the rotation. These new THPs were to be issued to the unit prior to their departing the CTC. While greatly increasing the timeliness of the THPs, the utility to the military research community was greatly diminished.

THPs were routinely sent to ARI-POM from the NTC, both in hard-copy and on diskette. The JRTC did not use the forms and sent much less information (Hutton,1995; Yother, 1995). However, since the JRTC was designated for use by light infantry forces and the NTC for heavy forces, it seems unlikely studies would be conducted across these two CTCs. The CMTC THPs were not submitted to ARI-POM in diskette form, hence the data extracted was labor intensive (Hutton, 1995; Keesling, 1995[6]).

The early THPs from the NTC involved a great deal of processing. They were created by compiling notes and remarks recorded by OCs for each mission, for each Co/Tm, and processed into BOS categories. Maps, overlays, and photos were included when requested. The effort required several weeks of work to complete, and at this time a copy was sent to home station and a copy sent to ARI-POM. THPs were a dense but extensive data source for much of the research conducted through the CTC Archive.

In 1989 an effort was undertaken to develop a DOS-based version of the THP database to integrate the hard-copy and word processed versions of the THP into the electronic database. In 1989, THPs were integrated into the digital database at ARI-POM (Lewman, et al., 1989). A methodology for extracting the relevant portions of the THPs was developed and implemented. By 1991, 39 rotations of THPs had been loaded into the THP database from the JRTC and the NTC. The CMTC had not submitted any THPs in any form.

NTC THPs typically cover six elements: Armor (A) Task Force, Mechanized (M) Infantry Task Force, Forward Support Battalion (FSB), Aviation (AVN), Field Artillery (FA) and Brigade operations (Bde) (Ford & Hamza, 1992). They contained the following sections: Executive Summary/Trends, Mission Statements, Lessons learned by BOS, Company/Team Lessons learned by BOS, and Battle Statistics (See Table 9.). In the early stages, the Company/Team THPs were submitted as a separate document, and were soon integrated into the Task Force THP.

The typical format for the JRTC THPs consisted of two annexes: Task Force Trends, and

[6]Personal conversation, September 1995

Company/Battery/Platoon Trends (See Table 10.). Emphasis was placed on trends exhibited throughout the rotation, systematic reporting of missions and battle statistics did not occur. However, the JRTC THPs were organized by BOS similar to the NTC THPs, and sometimes included selected battle statistics (Ford & Hamza, 1992).

Table 9. NTC THPs.

Section	Contents
Executive Summary/Trends	Overall performance. Trends and training recommendations by BOS
Mission Statements	OC description Direct quote from Commander
Battlefield Operating Systems Lessons learned	By BOS For each mission Performance within BOS by phase (Plan, Prepare, Execute) Lessons learned for each BOS Force on force missions followed by live fire. NCO Support and Individual Skills (if included) after BOS
Company/Team Operating Systems and Lessons learned	By Company Comments for each mission by phase Lessons learned.
Battle Statistics	Covers force on force missions Three parts per mission: Task Force losses broken out by ●OPFOR weapons ●Company/Team losses ●Weapon systems that caused OPFOR casualties.

Table 10. JRTC THPs.

Section	Contents
Task Force Trends	Comments grouped by BOS. Typically included: ●Critical Tasks ●Unit Strengths ●Areas in Need of Improvement ●Training Recommendations May include Mission Summary Battle statistics for selected units may be reported within BOS
Company/Battery/Platoon Trends	Comments grouped by unit. Typically included: ●Critical Tasks. ●Unit Strengths. ●Areas in need of Improvement. ●Training Recommendations

The CMTC produced very comprehensive THPs in paper copy only. The sections of the CMTC THPs consisted of a Mission Summary, Mission AAR Sheets, Operations Orders, AAR Slides, and a Fratricide Checklist (See Table 11.). Topics by BOS were systematically covered in the Description of Performance portion of the Mission Summary section (Ford & Hamza, 1992).

Table 11. CMTC THPs.

Section	Contents
Mission Summary	General Information: Enemy situation, friendly situation, mission statement, CDR's concept.
Mission AAR Sheets	Hand-written OC observations by BOS.
Operations Orders	Includes FRAGOs and graphics.
AAR Slides	Points emphasized in AAR for mission.
Fratricide Checklist	Description of fratricide and contributing factors (e.g., weather).

Company/Team Take-Home Packages

The Company/Team THPs were prepared by the TAF Division for each TF company/team based on instrumented data and input from OCs much like the TF THPs. The document described critical events in the Plan, Prepare, and Execute phases for each NTC mission for each Company/Team. These THPs were integrated into the Task Force THPs around 1987 and were only provided at the NTC. After 1994 rotation 9, company/teams were no longer included in the THPs at all.

Video Taped After Action Review (VAAR)

The VAARs were prepared by the TAF Division for each TF mission. The VAARs were a supplement to the THP to assist future home station training. The VAAR considered key to training effectiveness, was a tactical discussion among all soldiers. AARs provided a comprehensive summary of the battalion's training performance and were the most immediate feedback provided. The discussions were conducted by the senior trainer (OC) immediately following each mission training exercise (Ford & Hamza, 1992; Kemper, 1986). VAARs answered the questions:

'What happened'
'Why it happened'
'How to fix deficiencies'

In 1986, the VAARs were examined for research application and the compliance of OCs to the prototype VAAR (Zimmerman, Nichols, & Kemper, 1987). While substantive information was contained on the tapes (e.g., persistent criticism of communications, artillery, and fire support accuracy), the OCs did not follow the prototype which decreased the research utility of the tapes. Only half of the OCs reviewed the training objective for the mission, none of the OCs reviewed the task and subtasks from the ARTEPs, and only a few used the checklists created to standardize AARs (Shackelford, 1985). Platoon OCs almost never reviewed the TE&Os, and two-thirds of the Company OCs lectured rather than guided the feedback sessions. At the TF level, OCs followed the prototype more closely, but still rarely summarized events or results in relation to training objectives. Currently, it is recognized that OCs conduct feedback under the rubric of BOS at all echelons. Checklists and T&EOs were rarely used to guide feedback.

At each level of the brigade, AARs were streamlined to focus on specific tasks and training points. This allowed analysts to use the AARs in conjunction with other data to capture a more complete picture of battlefield events. However, as an independent research tool, utility was limited. The major objectives of the AAR remained generally the same throughout the time the CTC Archive remained at ARI-POM. The structure of the AARs were organized by battle phase (Plan, Prepare, Execute), the seven BOSs, and key events.

The objectives were (Ford & Hamza, 1992):

- Identify and highlight action and events by each primary area of responsibility critical to the mission outcome.
- Examine course of actions to note deviations from original plans using a participatory method versus lecture for generating an improved course of action to follow for subsequent missions.
- Analyze the effectiveness of major BOSs on the basis of critical points.

As of February 1994 (Ford & Hamza, 1992), the CTCs conducted routine AARs for Brigade, Task Force, Field Artillery, Aviation, and the Forward Support Battalion, and subordinate units. AARs continued to be conducted after each TF mission for all force-on-force and live fire exercises, of which there were 8 or 9 missions at NTC, 5 missions at JRTC, and 3 missions at CMTC. Company and platoon AARs were conducted in the field, but not all were taped. Special AARs which were more BOS specific were conducted by the Commander of the Operations Group (COG) before live fire exercises for each TF. Additional AARs were conducted for TF CSS, Scout Platoons, NBC, Engineers, and a Final AAR which was the summation of all missions.

Operations Plans

The Operations Plan is a planning document provided by the NTC to the TF controlling brigade to be executed by the battalion TFs at the NTC. Information typical of the Operations Plan included:

- Missions that will be executed
- General Astronomical data across the time period
- Scenario Plan
- Time/Event Schedule for Mechanized and Armor TFs, and Opposition Force (OPFOR)
- General Situation narrative describing a hostile international condition with potential for war between the two super-powers
- OPFOR and TF with General Situation Update(s)
- Analysis of Area Operations narrative with a General Description of the Area
- Defense Intelligence Report on the Handbook Krasnovian Army (OPFOR)
- Series of Operations Orders (OPORD), Warning Orders, and accompanying overlay maps

Operations Plans were received on paper and acetate. When technology advanced to the point where computers could "read" pictorial data, 1989, the Operations Plans were integrated into the digital database (Lewman, Zimmerman, Briscoe, Root, & Alan, 1989). Often the acetate and paper documents were too large to be "read" directly into the computer. Hence, an individual had

to reduce the size via photocopy machines, which involved a great deal of cutting and pasting. Later, circa 1991, video cameras could be used to "scan" the entire image and then "read" it into the computer.

By 1995, NTC was putting the Operations Plans and other graphics into the computer at the TAF. However, no software existed nor was implemented which would permit the overlays to be viewed in conjunction with the battle replays. At the time the CTC Archive was turned over to CALL, Ft. Leavenworth, efforts had been under way to join the computerized graphics with battle replays (Hutton, 1994).

Table 12. CTC Archive 1995 Summary of Contents

File Type	Files	Size
Automated Finder's Guide	18	584,898
CMTC Graphics Files	539	44,954,862
JRTC Archive Data	1,128	41,213,831
JRTC Graphics Files	308	49,209,382
JRTC THP Files	830	20,378,336
Mission Critical Event Sheet	515	875,938
NTC Archived Data	1,094	48,967,078
NTC Graphics Files	1,777	216,304,891
NTC Mission Database Files	8,417	1,862,946,174
NTC Replay Files	448	63,423,780
NTC THP Files	4,493	114,112,959

Unit After Action Reports (UAARs)

The UAARs were a detailed narrative and numerical description provided by the brigade commander to the division commander on the NTC training period. Recommendations for improving the NTC experience were provided. Basically, the UAARs were self-reports which sometimes contained a slightly different perspective than the THPs or AARs (Sulzen, 1995[7]). This data source was sent to ARI-POM in the early period, but discontinued shortly thereafter. The UAARs included (Kemper, 1986):

- Narrative Overview
- Each TF Commander's Comments

[7] Telephone conversation 28 September 1995.

- •Task Organization
- •Specific Comments and Recommendations on the seven BOS:
  - -Command & Control
  - -Maneuver
  - -Fire Support
  - -Intelligence
  - -Air Defense
  - -Mobility/Countermobility/Survivability (Survivability was a separate BOS during 1987)
  - -Combat Service Support
- •Numeric Data on:
  - -Maintenance
  - -Major Assembly Usage
  - -Vehicle Requirements
  - -Budget

Communications Tapes (with CEOIs)

Avant, Kemper, and Henderson (1986) examined the tapes to determine their research utility. The obtaining of data from this source was labor intensive. The recorded information does provide useful information and has been used to complement research efforts, however the extraction of the communications takes a great deal of time. The tapes consisted of 40-channels, all in operation simultaneously. Related documents were found to be absolutely necessary to make use of the commo tapes. The CEOIs were necessary to determine what channels and who was designated to use which channels. Commo cut sheets, daily commo log sheets, and tracking lists for both BLUFOR and OPFOR were likewise required. The machine required to playback the tapes was also very expensive. Frequency of communications was available through the digital data, so the efficiency of this effort remained dubious. Researchers sometimes used the tapes to gain a more comprehensive view, but the effort was labor intensive.

In 1991 Mulshine again reviewed the tapes for research applicability. ARI-POM facilitated its use by recording one channel at a time and eliminated long periods of silence. This was accomplished by a computerized program which turned on when voices were engaged and off when voices were silent (analog system). The cassettes contain a digital time signal on one channel, with the voice on the other channel; thus a researcher could identify when a transmission was occurring.

Communications tapes are a potentially rich data source which has been used when time permitted and the research indicated its usefulness (Jarrett, 1994). However, communications tapes will only be useful when technology is such that voice recognition, in combination with

noise-filtering can transcribe the communications to a time-tagged ASCII file which then could be combined with the other digital databases (Lewman, et al., 1992).

CONCLUSION

ARI-POM developed and delivered to TRADOC a modern, user-friendly, largely digital information system with the capability to derive institutional lessons for the Army from training conducted at the CTCs. The CTCs generate rich sources of data during the conduct of CTC training. Battalions have been performing three to five missions each rotation, under similar conditions for over 10 years. Currently, 33 units rotate through the CTCs yearly. ARI-POM successfully integrated 90% of the divergent data sources into an accessible database complete with tools and programs to assist analysts. Military analysts and researchers are now able to derive information remotely or on site using the tools and programs ARI-POM developed.

Insights useful to unit trainers are important. The current downsizing in force and budget means training dollars are also constrained. Additionally, unit post rotation turbulence has been often as high as 20% after one month, including primary staff positions. After three months, turbulence has been such that the unit conducting home station training was no longer the same unit that trained together at a CTC (Chapman, 1992; Keesling, 1993). The importance of deriving institutional lessons for the Army is more relevant now than ever. The CTC Operational Archive provides the tools required to derive needed lessons.

As the Army modernizes and its roles perhaps change, the CTC Archive has the potential to play a crucial role in deciding which 'improvements' contribute to the Army's ability to perform its missions and indicate when they do not. The advent of Force XXI and attendant new systems will require the Army to learn quickly and effectively. The CTC Archive provides the ability to examine the utility and effectiveness of new doctrine, organizations, training, materiel, and leadership.

ARI-POM introduced methods and programs with which to conduct studies and performed in-house research to support the Army. Doctrine, organization, training, materiel, and leadership (DOTML) were assessed with data processed at the CTC Archive. The CTC Archive demonstrated it could provide needed information for the Army.

"Those who cannot remember the past are condemned to repeat it." George Santayana.

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APPENDIX A
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